

MINERALS AND TRACE MINERALS

Mineral	Synthetic Name	Signs of Deficiency	Toxicity	Dietary Sources
Boron	boric acid, octoborate	Imbalance of calcium, magnesium and phosphorus, which may result in loss of bone mass and increased risk of arthritis	Dry skin, digestive upsets	Broccoli, pears, honey, chick peas, carrots, beans, bananas, red apples, beans, lentils
Calcium	calcium ascorbate, calcium carbonate, calcium caseinate, calcium chloride, calcium citrate, calcium gluconate, calcium glycerophosphate, calcium hydroxyapatite, calcium, calcium iodide, calcium lactate, calcium oxide, pantothenate, calcium phosphates, calcium propionate, calcium stearate, calcium sulfate	lameness, bone demineralization, and an increased incidence of fractures. During lactation, signs include seizures and tetany (eclampsia)	Excess intake of calcium results in growth retardation and severe bone and joint abnormalities	Fish, bones, dairy, egg shells, spinach, beans, broccoli
Copper	copper sulfate, copper sulfide	Loss of hair and skin color, anemia, improper bone formation.	Liver damage	Kale, spinach, beet greens, asparagus, swiss chard, pumpkin seeds, flax seeds, chick peas, kidney beans
Iron	ferrous lactate, ferrous sulfate, ferrous fumarate, iron peptonate, ferrous gluconate, ferric pyrophosphate	Anemia, fatigue, poor stamina, intestinal bleeding, nervousness, heart palpitations and shortness of breath	Weight loss, loss of appetite, and death. Iron over-supplementation can also contribute to reduced zinc absorption, heart disease and the hardening of arteries	Rabbit, chicken, turkey, pork, lamb, goat, ostrich, buffalo, egg, beef, salmon, halibut, haddock, sardine, squash, pumpkin, spinach, swiss chard, kale, broccoli, beet greens, lima beans, kidney beans, lentils
Magnesium	magnesium oxide, magnesium sulfate, magnesium carbonate, magnesium chloride, magnesium citrate	Cardiovascular problems, weakness, seizures, hypertension. Seizures are often seen in dogs suffering from magnesium deficiency and can often be treated with a magnesium supplement	Diarrhea and gas.	Rabbit, chicken, turkey, pork, goat, ostrich, buffalo, egg, beef, salmon, halibut, haddock, sardine

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Manganese	manganese gluconate, manganese dioxide, manganese sulfate	Poor bone growth, problems with blood glucose levels, decreased reproductive performance, abortion, stiffness, and bone abnormalities	Loss of appetite, reduction in blood pressure with reflex tachycardia, and a marked increase in liver enzymes	Rabbit, chicken, turkey, pork, goat, ostrich, buffalo, egg, beef, salmon, haddock, halibut, sardine spinach, pumpkin seeds, flax seed, sunflower seeds, kidney beans, chick peas
Phosphorus	phosphorus pentachloride	A deficiency of phosphorus is very rare. A sign of deficiency is deprived appetite	Excess phosphorus ingestion usually results from feeding an all meat diet, which results in a calcium deficiency. Also promotes kidney damage.	Beef, Chicken breast, chicken backs, chicken wings, turkey necks, beef bonemeal, rabbit, turkey, pork, lamb, goat, ostrich, buffalo, egg, salmon, halibut, haddock, sardine
Potassium	potassium chloride, potassium nitrate, potassium bromate, potassium sorbate, potassium iodide, potassium sulfate	Fatigue/listlessness, poor growth, dry skin, loss of hair, muscular paralysis, dehydration, lesions on heart and kidneys	High blood pressure and loss of calcium in the body. Excess potassium is generally not a problem unless the animal suffers from kidney failure	Rabbit, chicken, turkey, pork, lamb, goat, ostrich, buffalo, egg, beef, salmon, halibut, haddock, sardine
Silicon	silicon dioxide, silicon carbide	Teeth, bone and joint problems, hardening of the arteries. When dogs eat grass or dirt, they often have a need for additional silicon in their diet	None reported	Organ meats, green beans, bananas, spinach, asparagus, cucumber

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Sulfur	sulphuric acid, sulphur trioxide, sulfur dioxide, sulfur oxide	Coat discoloration, skin conditions (hot spots, eczema, dermatitis, allergies). Sulfur is absorbed in the intestine and a deficiency may occur when antibiotic treatment has destroyed the colony of intestinal bacteria, so feeding a probiotic supplement together with a sulfur supplement is beneficial. The best form of sulfur supplement is methylsulfonyl methane (MSM)	None reported	Methylsulfonylmethane is an organic form of sulfur which return to the earth via rainwater. Fruits and vegetables absorb the rainwater so MSM can be found in most plants. Also, grazing animals will assimilate MSM. Raw milk will contain MSM. Cooking, freezing, heating and irradiation will destroy most natural forms of MSM in plants and meat.
Sodium	sodium selenite, sodium nitrate, sodium hydroxide, sodium bisulfate, sodium caseinate, sodium hexametaphosphate	Fatigue/listlessness, poor growth, dry skin, loss of hair, muscular paralysis, dehydration, lesions on heart and kidneys	High blood pressure and loss of calcium in the body. Excess potassium is generally not a problem unless the animal suffers from kidney failure	Shellfish, eggs, dairy, swiss chard, beet greens, collard greens, dandelion greens, spinach, garbanzo beans, mung beans
Zinc	zinc oxide, zinc sulfide, zinc acetate, zinc carbonate, zinc chloride, zinc citrate, zinc gluconate, zinc lactate, zinc monomethionine	Skin problems, dry coat, excessive shedding, fading hair color, growth retardation, a weakened immune system, and poor reproductive performance	Excess zinc intake results in vomiting, and may interfere with the absorption of other minerals such as copper and iron	Liver, rabbit, chicken, turkey, pork, lamb, goat, ostrich, buffalo, egg, beef, salmon, halibut, haddock, sardine, pumpkin seeds, spinach, kidney beans

Metabolizable Energy

$$ME \text{ (kcal/kg)} = 8(3.5 \times CP) + (8.5 \times CF) + (3.5 \times NFE)$$

(Protein) (Fat) (Carbohydrate)